

Glove Permeation with a Dextrous Robot Hand System

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A. Background

The standard ASTM F739-99a permeation test does not account for finger movement /clenching.

A dextrous robotic hand model (Figure 1; ref 1) does allow a whole glove to be tested (Figure 2) for these factors, rather than a flat piece of glove used in the ASTM permeation cell (Figure 3)



Figure 1. Yaeger dextrous robot hand with test tube fingers/thumb



Figure 2 Gloved dextrous robotic hand

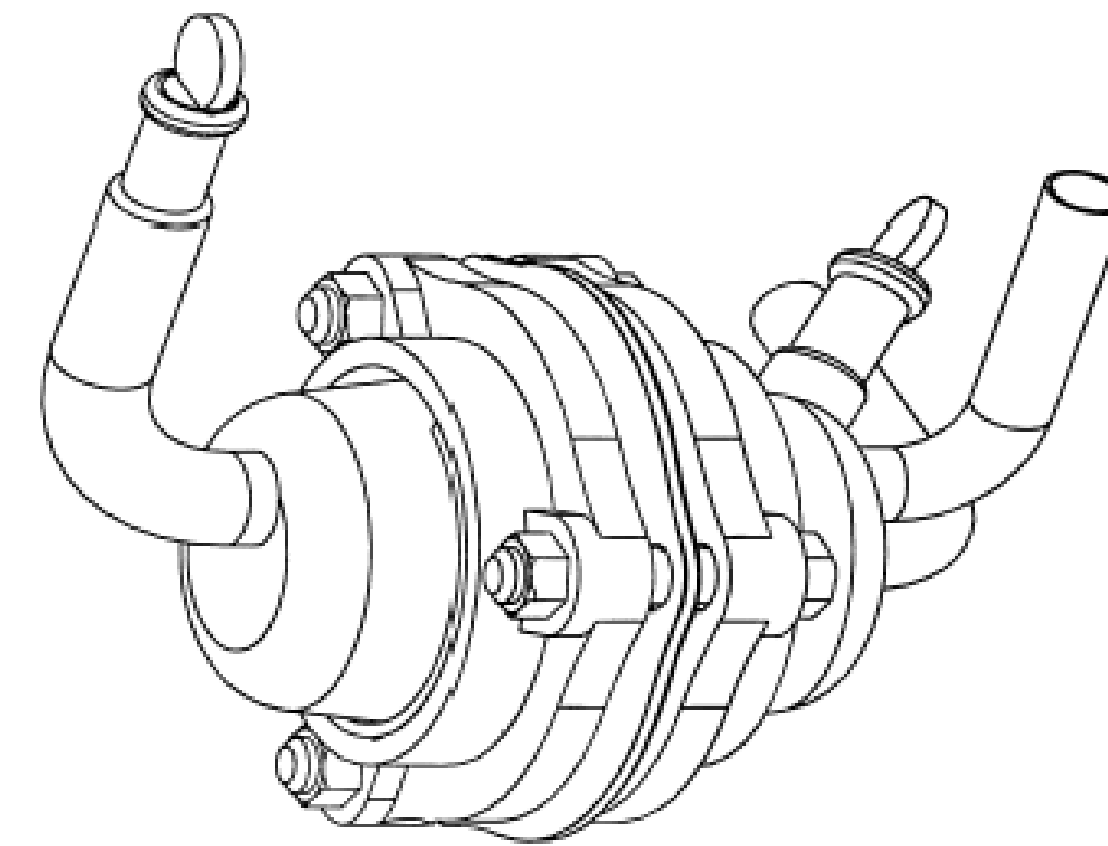


Figure 3 ASTM F739-99a permeation cell

B. Experimental

- Glove: disposable nitrile gloves (Kimberly-Clark SafeSkin™ blue)
- Glove Measurements: thickness; diameter; Reflectance infrared
- Challenge: amyl acetate (148), aniline (184), benzaldehyde (179), benzotrichloride (213), benzyl alcohol (secondary reference, 206), benzyl chloride (179), butylcarbitol (231), butylcellosolve (170), butyrolactam (245), cellosolve acetate (156), chloronaphthalene (250), 2-chlorophenol (176), 2-chlorotoluene (159), 3-chlorotoluene (161), 4-chlorotoluene (164), cyclohexanol (161), cyclohexanone (157), 1,5-cyclooctadiene (151), diacetone alcohol (167), dibutylphthalate (340), dimethylacetamide (166), dimethylformamide (152), ethylene glycol (198), ethyl glycollether (170), furfural (162), 1-heptanol (176), methyl amylketone (150), nitrobenzene (211), octanol (195), oleic acid (360), styrene (145), tricresyl phosphate (420), and triethanolamine (360). Note: The numbers in parentheses are boiling points
- Collection Solvent: Water
- Permeation Cell: 1 inch permeation cells (Pesce Lab), based on the standard American Society for Testing and Materials (ASTM) F739-99a permeation method (Figure 3)
- Temperature: $35.0 \pm 0.5^\circ\text{C}$; water bath
- Average Horizontal Shaking Speed: 70 ± 5 cycles per minute at 10.24 cm cycle
- Evaporation of Final Collection Solutions in V-vials: $35 \pm 3^\circ\text{C}$ under nitrogen flow (Evaporation method validated)
- Analysis: capillary gas chromatography-mass spectrometry (GC-MS) analysis; internal standard method

C. Results

Screening Immersion Results for Degradation (irreversible swelling/shrinking/no hole formation/wrinkling/discoloration)

2-chlorophenol; cyclohexanol; diacetone alcohol; ethylene glycol; octanol; tricresyl phosphate; and triethanolamine were suitable

Screening for Water Solubility: 2-chlorophenol; cyclohexanol; diacetone alcohol; ethylene glycol, and triethanolamine were suitable for water collection solvent in ASTM closed loop system for screening tests

Closed Loop ASTM Cell Screening: ethylene glycol and triethanolamine did not surpass the critical threshold of 250 ng/cm^2 before 8 hours.

Cyclohexanol : steady state permeation rate = $5.7 \pm 1.3 \mu\text{g cm}^{-2} \text{ h}^{-1}$ (range:2.01-7.59)

lag time: $108 \pm 11 \text{ min}$ (range: 96.2-110.5 min)

normalized breakthrough time: 0-60 min (still being defined)

D. Conclusions

- The screening battery identified cyclohexanol as one chemical to define the effects of finger motion and fist clenching for a dextrous robot hand model on normalized breakthrough time and steady state permeation rate
- Experiments are to be continued
- Hexafluorohexane will be used as the collection solvent for water insoluble chemicals

E. Acknowledgments

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F. Reference

(1) Phalen Jr., R.E., Que Hee, S.S. J Occup Env Hyg 5: 258-270, 2008.

